```
======================================================================== Virgin
                                                                         Virgin
     PROGRAM VIRGIN                                                      Virgin
     VERSION 76-1 (NOVEMBER 1976)                                        Virgin
     VERSION 84-1 (JUNE 1984)    *DOUBLE PRECISION ENERGY                Virgin
     VERSION 86-1 (JANUARY 1986)*FORTRAN-77/H VERSION                    Virgin
     VERSION 88-1 (JULY 1988)    *OPTION...INTERNALLY DEFINE ALL I/O     Virgin
                                  FILE NAMES (SEE, SUBROUTINE FILEIO     Virgin
                                  FOR DETAILS).                          Virgin
                                 *IMPROVED BASED ON USER COMMENTS.       Virgin
     VERSION 89-1 (JANUARY 1989)*PSYCHOANALYZED BY PROGRAM FREUD TO      Virgin
                                  INSURE PROGRAM WILL NOT DO ANYTHING    Virgin
                                  CRAZY.                                 Virgin
                                 *UPDATED TO USE NEW PROGRAM CONVERT     Virgin
                                  KEYWORDS.                              Virgin
                                 *ADDED LIVERMORE CIVIC COMPILER         Virgin
                                  CONVENTIONS.                           Virgin
     VERSION 92-1 (JANUARY 1992)*COMPLETE RE-WRITE                       Virgin
                                 *OUTPUT IN PLOTTAB FORMAT               Virgin
                                 *UP TO 2000 THICKNESSES                 Virgin
                                 *INCREASED INCORE PAGE SIZE TO 6000     Virgin
                                  CROSS SECTION POINTS                   Virgin
                                 *ADDED PHOTON CALCULATIONS              Virgin
                                 *ADDED BLACKBODY SPECTRUM               Virgin
                                 *ADDED MULTIPLE LAYERS                  Virgin
                                 *ADDED SPATIALLY DEPENDENT DENSITY      Virgin
                                 *ADDED FORTRAN SAVE OPTION              Virgin
                                 *COMPLETELY CONSISTENT I/O ROUTINES -   Virgin
                                  TO MINIMIZE COMPUTER DEPENDENCE.       Virgin
     VERSION 92-2 (MAY 1992)     *CORRECTED TO HANDLE MULTIGROUP CROSS   Virgin
                                  SECTIONS AS INPUT IN ENDF/B FORMAT.    Virgin
     VERSION 96-1 (JANUARY 1996) *COMPLETE RE-WRITE                      Virgin
                                  *IMPROVED COMPUTER INDEPENDENCE        Virgin
                                  *ALL DOUBLE PRECISION                  Virgin
                                  *ON SCREEN OUTPUT                      Virgin
                                  *UNIFORM TREATMENT OF ENDF/B I/O       Virgin
                                  *IMPROVED OUTPUT PRECISION             Virgin
                                  *DEFINED SCRATCH FILE NAMES            Virgin
     VERSION 99-1 (MARCH 1999)    *CORRECTED CHARACTER TO FLOATING       Virgin
                                   POINT READ FOR MORE DIGITS            Virgin
                                  *UPDATED TEST FOR ENDF/B FORMAT        Virgin
                                   VERSION BASED ON RECENT FORMAT CHANGE Virgin
                                  *GENERAL IMPROVEMENTS BASED ON         Virgin
                                   USER FEEDBACK                         Virgin
     VERS. 2000-1 (FEBRUARY 2000)*GENERAL IMPROVEMENTS BASED ON         Virgin
                                   USER FEEDBACK                         Virgin
     VERS. 2002-1 (MAY 2002)      *OPTIONAL INPUT PARAMETERS             Virgin
     VERS. 2004-1 (MARCH 2004)    *ADDED INCLUDE FOR COMMON              Virgin
                                  *UP TO 2000 THICKNESSES                Virgin
                                  *INCREASED INCORE PAGE SIZE TO 60,000  Virgin
     VERS. 2007-1 (JAN.  2007)    *CHECKED AGAINST ALL ENDF/B-VII.       Virgin
                                  *INCREASED INCORE PAGE SIZE TO         Virgin
                                   240,000 FROM 60,000.                  Virgin
     VERS. 2007-2 (DEC.  2007)    *72 CHARACTER FILE NAME.               Virgin
     VERS. 2010-1 (Apr.  2010)    *General update based on user feedback Virgin
                                  *INCREASED INCORE PAGE SIZE TO         Virgin
                                   600,000 FROM 240,000.                 Virgin
     VERS. 2012-1 (Aug.  2012)    *Added CODENAME                        Virgin
                                  *32 and 64 bit Compatible              Virgin
                                  *Added ERROR stop                      Virgin
     VERS. 2015-1 (Jan.  2015)    *Extended OUT9.                        Virgin
                                  *Replaced ALL 3 way IF Statements.     Virgin
                                  *Generalized TART Group Structures.    Virgin
```

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                          *Generalized SAND-II Group Structures. Virgin
                          *Extended SAND-II to 60, 150, 200 MeV. Virgin
VERS. 2015-2 (Apr.  2015) *Changed ALL data to "D" instead of    Virgin
                           "E" to insure it is REAL*8 and avoid  Virgin
                           Truncation ERRORS.                    Virgin
VERS. 2017-1 (May   2017) *Added UKAEA 1102 Group Structure.     Virgin
                          *Increased points to 3,000,000        Virgin
                          *Increased groupd to 30,000           Virgin
                          *Updated based on user feedback       Virgin
                          *Defintion of built-in group structure Virgin
                           using SUBROUTINE GROPE is identical  Virgin
                           for GROUPIE and VIRGIN.              Virgin
                          *All floating point parameters changed Virgin
                           to character inout + IN9 conversion. Virgin
                                                                Virgin
2015-2 Acknowledgment                                           Virgin
======================                                          Virgin
I thank Andrej Trkov (NDS, IAEA) for finding the problem with   Virgin
the "E" formatted DATA (this effected both VIRGIN and GROUPIE).  Virgin
I also thank Andrej for overseeing the entire PREPRO project    Virgin
at IAEA, Vienna; he is part of a truly International team who   Virgin
worked together to produce PREPRO-2015-2, and to make it        Virgin
available Internationally on-line for FREE to ALL users.        Virgin
                                                                Virgin
OWNED, MAINTAINED AND DISTRIBUTED BY                            Virgin
-----------------------------------                             Virgin
THE NUCLEAR DATA SECTION                                        Virgin
INTERNATIONAL ATOMIC ENERGY AGENCY                              Virgin
P.O. BOX 100                                                    Virgin
A-1400, VIENNA, AUSTRIA                                         Virgin
EUROPE                                                          Virgin
                                                                Virgin
ORIGINALLY WRITTEN BY                                           Virgin
-------------------------------------                           Virgin
Dermott E. Cullen                                               Virgin
                                                                Virgin
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                                                                Virgin
PURPOSE                                                         Virgin
-------                                                         Virgin
THIS PROGRAM IS DESIGNED TO CALCULATE UNCOLLIDED (I.E. VIRGIN)  Virgin
FLUX AND REACTIONS DUE TO TRANSMISSION OF A MONODIRECTIONAL      Virgin
BEAM OF NEUTRONS THROUGH ANY THICKNESS OF MATERIAL. IN ORDER    Virgin
TO SIMULATE AN EXPERIMENTAL MEASUREMENT THE RESULTS ARE GIVEN   Virgin
AS INTEGRALS OVER ENERGY TALLY GROUPS (AS OPPOSED TO POINTWISE  Virgin
IN ENERGY). BY TAKING THE RATIO OF REACTIONS TO FLUX IN EACH     Virgin
GROUP AN EQUIVALENT SPATIALLY DEPENDENT GROUP AVERAGED CROSS    Virgin
SECTION IS CALCULATED BY THE PROGRAM.                           Virgin
                                                                Virgin
EVALUATED DATA                                                  Virgin
--------------                                                  Virgin
THE EVALUATED DATA MUST BE IN THE ENDF/B FORMAT. HOWEVER IT     Virgin
MUST BE LINEAR-LINEAR INTERPOLABLE IN ENERGY-CROSS SECTION      Virgin
BETWEEN TABULATED POINTS. SINCE ONLY CROSS SECTIONS (FILE 3 OR 23) Virgin
ARE USED, THIS PROGRAM WILL WORK ON ANY VERSION OF ENDF/B       Virgin
```

(I.E. ENDF/B-I, II, III, IV, V OR VI).

RELATED COMPUTER CODES

IN ORDER TO CONVERT ENDF/B DATA TO THE FORM REQUIRED BY THIS CODE THE FOLLOWING COMPUTER CODES MAY BE USED,

LINEAR - CONVERT FROM GENERAL ENDF/B INTERPOLATION TO LINEAR-LINEAR INTERPOLATION.
RECENT - ADD THE RESONANCE CONTRIBUTION TO TABULATED BACKGROUND CROSS SECTIONS TO OBTAIN LINEAR-LINEAR INTERPOLABLE RESULTS.
SIGMA1 - DOPPLER BROADEN CROSS SECTION TO OBTAIN LINEAR-LINEAR INTERPOLABLE RESULTS.
MIXER - MIX INDIVIDUAL MATERIALS TOGETHER TO DEFINE COMPOSITE MIXTURES, E.G., COMBINE MATERIALS TO DEFINE STAINLESS STELL.

IN ORDER TO PLOT THE OUTPUT RESULTS OF THIS CODE USE PROGRAM PLOTTAB.

COPIES OF ANY OR ALL OF THESE CODES MAY BE OBTAINED FROM D.E. CULLEN AT THE ABOVE ADDRESS.

OUTPUT FORMAT

FOR ALL VERSIONS OF THIS PROGRAM PRIOR TO VERSION 92-1 OUTPUT WAS IN TABULAR FORM.

FOR VERSION 92-1 AND LATER VERSIONS OF THIS CODE ALL OUTPUT IS IN THE PROGRAM PLOTTAB FORMAT TO ALLOW RESULTS TO BE EASILY PLOTTED. FOR A COPY OF PROGRAM PLOTTAB CONTACT D.E. CULLEN AT THE ABOVE ADDRESS.

TALLY GROUPS

THE TALLY GROUP STRUCTURE MAY BE ANY SET OF MONONTONICALLY INCREASING ENERGY BOUNDARIES. THERE MAY BE UP TO 2000 TALLY GROUPS. BY USING THE INPUT PARAMETERS THE USER MAY SPECIFY ANY ARBITRARY TALLY GROUP STRUCTURE OR SELECT ONE OF THE FOLLOWING BUILT-IN GROUP STRUCTURES.

(0) TART 175 GROUPS
(1) ORNL 50 GROUPS
(2) ORNL 126 GROUPS
(3) ORNL 171 GROUPS
(4) SAND-II 620 GROUPS - 1.0D-4 eV UP TO 18 MEV
(5) SAND-II 640 GROUPS - 1.0D-4 eV UP TO 20 MEV
(6) WIMS 69 GROUPS
(7) GAM-I 68 GROUPS
(8) GAM-II 99 GROUPS
(9) MUFT 54 GROUPS
(10) ABBN 28 GROUPS
(11) TART 616 GROUPS TO 20 MeV
(12) TART 700 GROUPS To 1 GeV
(13) SAND-II 665 GROUPS - 1.0D-5 eV UP TO 18 MEV
(14) SAND-II 685 GROUPS - 1.0D-5 eV UP TO 20 MEV
(15) TART 666 GROUPS TO 200 MeV
(16) SAND-II 725 GROUPS - 1.0D-5 eV UP TO 60 MEV
(17) SAND-II 755 GROUPS - 1.0D-5 eV UP TO 150 MEV
(18) SAND-II 765 GROUPS - 1.0D-5 eV UP TO 200 MEV
(19) UKAEA 1102 GROUPS - 1.0D-5 eV UP TO 1 GeV

INCIDENT SPECTRUM Virgin
---------- Virgin
THE INCIDENT SPECTRUM MAY BE ANY TABULATED FUNCTION THAT IS Virgin
GIVEN BY A SET OF POINTS THAT IS MONOTONICALLY INCREASING IN Virgin
ENERGY AND LINEAR-LINEAR INTERPOLABLE IN ENERGY-SPECTRUM Virgin
BETWEEN TABULATED POINTS. THERE IS NO LIMIT TO THE NUMBER OF Virgin
POINTS USED TO DESCRIBE THE SPECTRUM. THERE ARE FIVE BUILT-IN Virgin
OPTIONS FOR THE SPECTRUM. Virgin
Virgin
(1) CONSTANT...ENERGY INDEPENDENT (INPUT 0) Virgin
(2) 1/E (INPUT 1) Virgin
(3) BLACKBODY - PHOTON SPECTRUM Virgin
(4) BLACKBODY - ENERGY SPECTRUM (E TIMES THE PHOTON SPECTRUM) Virgin
(5) TRANSMITTED SPECTRUM FROM PREVIOUS CASE Virgin
Virgin
NORMALIZATION OF SPECTRUM Virgin
---------- Virgin
ANY INCIDENT SPECTRUM, EITHER READ AS INPUT OR ONE OF THE Virgin
BUILT-IN SPECTRA, WILL BE NORMALIZED TO UNITY WHEN INTEGRATED Virgin
OVER THEIR ENTIRE ENERGY RANGE. Virgin
Virgin
TRANSMITTED SPECTRA WILL NOT BE RE-NORMALIZED, SINCE IT ALREADY Virgin
INCLUDES THE NORMALIZATION OF THE INCIDENT SPECTRUM. Virgin
Virgin
NOTE, INCIDENT SPECTRA IS NORMALIZED TO UNITY OVER THEIR ENTIRE Virgin
ENERGY RANGE - NOT OVER THE ENERGY RANGE OF THE GROUPS. IF THE Virgin
ENERGY RANGE OF THE GROUPS IS LESS THAN THAT OF THE SPECTRUM Virgin
ONLY THAT PORTION OF THE SPECTRUM WILL BE USED AND THIS WILL Virgin
NOT BE RE-NORMALIZED TO UNITY. Virgin
Virgin
COMPOSITION OF A LAYER Virgin
---------- Virgin
YOU MAY RUN PROBLEMS INVOLVING Virgin
1) A LAYER OF UNIFORM DENSITY - DENSITY FOR ATTENUATION IS THAT Virgin
   OF THE TOTAL. DENSITY FOR REACTIONS IS THAT OF THE REACTION. Virgin
2) A LAYER OF UNIFORM DENSITY - DENSITY IS THE SUM OF THE TOTAL Virgin
   AND REACTION DENSITIES - THE SUM OF THE CROSS SECTIONS IS Virgin
   USED FOR ATTENUATION AND REACTIONS. Virgin
3) A LAYER OF VARYING DENSITY BASED ON A UNIFORM TOTAL DENSITY Virgin
   PLUS A VARIATION BETWEEN 0 AND A MAXIMUM BASED ON THE Virgin
   REACTION DENSITY - 0 AT 0 THICKNESS AND MAXIMUM AT MAXIMUM Virgin
   THICKNESS. IN THIS CASE THE AVERAGE REACTION DENSITY IS EQUAL Virgin
   TO THE INPUT REACTION DENSITY. THE VARIATION IN REACTION Virgin
   DENSITY CAN BE LINEAR, SQUARE OR CUBIC. Virgin
4) A LAYER OF VARYING DENSITY BASED ON A TOTAL DENSITY WHICH Virgin
   VARYING FROM MAXIMUM AT 0 THICKNESS TO 0 AT MAXIMUM THICKNESS Virgin
   PLUS A REACTION DENSITY WHICH VARIES FROM 0 AT 0 THICKNESS Virgin
   TO MAXIMUM AT MAXIMUM THICKNESS. IN THIS CASE THE AVERAGE Virgin
   DENSITY OF THE TOTAL AND REACTION WILL BOTH BE EQUAL TO THE Virgin
   INPUT TOTAL AND REACTION DENSITIES. THE VARIATION IN TOTAL Virgin
   AND REACTION DENSITY CAN BE LINEAR, SQUARE OR CUBIC. Virgin
Virgin
IN THE FIRST CASE THE TWO REQUESTED CROSS SECTIONS ARE CONSIDERED Virgin
TO BE INDEPENDENT - THE TOTAL CROSS SECTION IS USED TO CALCULATE Virgin
ATTENUATION AND THE REACTION CROSS SECTION IS USED TO CALCULATE Virgin
REACTIONS, E.G., TRANSMISSION THROUGH NATURAL URANIUM (THE TOTAL Virgin
CROSS SECTION SHOULD BE THAT OF NATURAL URANIUM) AND REACTIONS Virgin
IN A U-235 DETECTOR (THE REACTION CROSS SECTION SHOULD BE THAT OF Virgin
U-235). Virgin
Virgin
IN THE OTHER THREE CASES THE TWO REQUESTED CROSS SECTIONS ARE Virgin
TREATED AS TWO CONSTITUENTS OF A MIXTURE OF TWO MATERIALS AND Virgin
THE TWO CROSS SECTIONS ARE USED BOTH TO DEFINE A TOTAL CROSS Virgin

SECTION FOR ATTENUATION AND A REACTION CROSS SECTION TO DEFINE Virgin
REACTIONS. IN THESE CASES THE MIXTURE WILL VARY CONTINUOUSLY, Virgin
E.G., IN CASE 4) HALF WAY THROUGH THE LAYER THE COMPOSITION WILL Virgin
BE 1/2 THE MATERIAL DEFINED BY THE TOTAL AND 1/2 THE MATERIAL Virgin
BASED ON THE REACTION. IN THESE CASES RATHER THAN THINKING OF Virgin
THE TWO CROSS SECTIONS AS A TOTAL AND REACTION CROSS SECTION, Virgin
IT IS BETTER TO THINK OF THEM AS THE TOTAL CROSS SECTIONS FOR Virgin
MATERIALS A AND B AND THE CALCULATED REACTIONS WILL BE BASED Virgin
ON THESE TWO TOTAL CROSS SECTIONS. Virgin
Virgin

MULTIPLE LAYERS Virgin
--- Virgin
THIS CODE MAY BE USED TO RUN EITHER A NUMBER OF INDEPENDENT Virgin
PROBLEMS, EACH INVOLVING TRANSMISSION THROUGH A SINGLE LAYER OF Virgin
MATERIAL, OR TRANSMISSION THROUGH A NUMBER OF LAYERS ONE AFTER Virgin
THE OTHER. Virgin
Virgin

IN THE CASE OF MULTIPLE LAYERS, ONE LAYER AFTER ANOTHER, THE Virgin
TRANSMITTED ENERGY DEPENDENT SPECTRUM IS USED AS THE INCIDENT Virgin
SPECTRUM FOR THE NEXT LAYER. THERE IS NO LIMIT TO THE NUMBER Virgin
OF LAYERS WHICH MAY BE USED - EACH LAYER IS TREATED AS A Virgin
COMPLETELY INDEPENDENT PROBLEM WITH A DEFINED INCIDENT SOURCE, Virgin
AND AS SUCH THE CYCLE OF TRANSMISSION THROUGH EACH LAYER AND Virgin
USING THE TRANSMITTED SPECTRUM AS THE INCIDENT SPECTRUM FOR THE Virgin
NEXT LAYER MAY BE REPEATED ANY NUMBER OF TIMES. Virgin
Virgin

REMEMBER - THE INCIDENT SPECTRUM IS ASSUMED TO BE LINEARLY Virgin
INTERPOLABLE IN ENERGY AND SPECTRUM BETWEEN THE ENERGIES AT Virgin
WHICH IT IS TABULATED. THE TRANSMITTED SPECTRUM WILL BE TABULATED Virgin
AT THE UNION OF ALL ENERGIES OF THE INCIDENT SPECTRUM AND CROSS Virgin
SECTIONS (TOTAL AND REACTION). IN ORDER TO INSURE THE ACCURACY Virgin
OF THE RESULT WHEN PERFORMING MULTIPLE LAYER CALCULATION BE SURE Virgin
TO SPECIFY THE INCIDENT SPECTRUM ON THE FIRST LAYER TO SUFFICIENT Virgin
DETAIL (ENOUGH ENERGY POINTS CLOSELY SPACED TOGETHER) IN ORDER TO Virgin
ALLOW THE TRANSMITTED SPECTRUM TO BE ACCURATELY REPRESENTED BY Virgin
LINEAR INTERPOLATION BETWEEN SUCCESSIVE ENERGY POINTS - THERE IS Virgin
NO LIMIT TO THE NUMBER OF POINTS ALLOWED IN THE INCIDENT SPECTRUM, Virgin
SO IF YOU ARE IN DOUBT, SIMPLY USE MORE ENERGY POINTS TO SPECIFY Virgin
THE INCIDENT SPECTRUM. Virgin
Virgin

RESULT OUTPUT UNITS Virgin
--- Virgin
FLUX = EXACTLY AS CALCULATED Virgin
REACTIONS = 1/CM OR 1/GRAM Virgin
AVERAGE = 1/CM - MACROSCOPIC UNITS Virgin
CROSS Virgin
SECTION Virgin
Virgin

THICKNESS AND DENSITY Virgin
--- Virgin
THE UNCOLLIDED CALCULATION ONLY DEPENDS ON THE PRODUCT OF Virgin
THICKNESS AND DENSITY (I.E. GRAMS PER CM SQUARED). THIS FACT Virgin
MAY BE USED TO SIMPLIFY INPUT BY ALLOWING THE THICKNESS AND Virgin
DENSITY TO BE GIVEN EITHER AS CM AND GRAMS/CC RESPECTIVELY Virgin
OR ELSE TO GIVE THICKNESS IN GRAMS/(CM*CM) AND INPUT A Virgin
DENSITY OF 1.0 - OR IN ANY OTHER CONVENIENT UNITS AS LONG AS Virgin
THE PRODUCT OF THICKNESS AND DENSITY IS IN THE CORRECT GRAMS Virgin
PER CENTIMETER SQUARED. Virgin
Virgin

GRAMS/(CM*CM) ARE RELATED TO ATOMS/BARN THROUGH THE RELATIONSHIP Virgin
Virgin

GRAMS/(CM*CM)=(ATOMS/BARN)*(GRAMS/MOLE)*(MOLE/ATOM) Virgin
Virgin

OR... Virgin

Virgin

GRAMS/(CM*CM)=(ATOMS/BARN)*(ATOMIC WEIGHT)/0.602 Virgin

Virgin

CROSS SECTIONS AT A SPACE POINT AND OPTICAL THICKNESS Virgin

---------- Virgin

THIS PROGRAM ALLOWS LAYERS OF EITHER UNIFORM DENSITY OR Virgin

CONTINUOUSLY VARYING DENSITY. THE DENSITY CAN BE ONE OF THE Virgin

FOLLOWING FORMS, Virgin

1) C = UNIFORM DENSITY Virgin

2) C*2*(X/T) = LINEAR VARIATION FROM 0 TO C Virgin

3) C*(2-2*(X/T)) = LINEAR VARIATION FROM C TO 0 Virgin

4) C*3*(X/T)**2 = SQUARE VARIATION FROM 0 TO C Virgin

5) C*(3-3*(X/T)**2)/2 = SQUARE VARIATION FROM C TO 0 Virgin

6) C*4*(X/T)**3 = CUBIC VARIATION FROM 0 TO C Virgin

7) C*(4-4*(X/T)**3)/3 = CUBIC VARIATION FROM C TO 0 Virgin

Virgin

IN ORDER TO CALCULATE REACTIONS AT A POINT THE MICROSCOPIC Virgin

REACTION CROSS SECTION NEED MERELY BE SCALED BY THESE DENSITIES. Virgin

Virgin

IN ORDER TO CALCULATE TRANSMISSION WE MUST DEFINE THE OPTICAL Virgin

PATH LENGTH WHICH MAY BE DEFINED BY INTEGRATING EACH OF THE Virgin

ABOVE DENSITY FORMS TO FIND, Virgin

1) C*X Virgin

2) C*X*(X/T) Virgin

3) C*X*(2-(X/T)) Virgin

4) C*X*(X/T)**2 Virgin

5) C*X*(3-(X/T)**2)/2 Virgin

6) C*X*(X/T)**3 Virgin

7) C*X*(4-(X/T)**3))/3 Virgin

Virgin

IN ORDER TO CALCULATE TRANSMISSION TO A POINT THE MICROSCOPIC Virgin

TOTAL CROSS SECTION NEED MERELY BE SCALED BY THESE DENSITIES Virgin

TO DEFINE THE OPTICAL PATH LENGTH. Virgin

Virgin

THE VARIATION OF THE DENSITY THROUGH THE LAYER MAY BE DEFINED Virgin

BY SETTING X = 0 OR X = T TO FIND, Virgin

	X = 0	X = T	
	-----	-----	Virgin
1)	C	C	Virgin
2)	0	2*C	Virgin
3)	2*C	0	Virgin
4)	0	3*C	Virgin
5)	3*C/2	0	Virgin
6)	0	4*C	Virgin
7)	4*C/3	0	Virgin

Virgin

THE OPTICAL PATH THROUGH A LAYER OF THICKNESS T MAY BE DEFINED Virgin

FROM THE ABOVE EXPRESSIONS BY SETTING X=T TO FIND THAT IN ALL Virgin

CASES THE ANSWER WILL BY C*T. THE CONSTANTS IN THE ABOVE Virgin

EXPRESSIONS HAVE BEEN INTRODUCED IN ORDER TO FORCE THIS RESULT. Virgin

WITH THESE FACTORS THE OPTICAL PATH LENGTH THROUGH THE LAYER Virgin

WILL EXACTLY CORRESPOND TO AN AVERAGE DENSITY CORRESPONDING TO Virgin

THAT INPUT FOR THE TOTAL AND/OR REACTION, I.E., C CORRESPONDS Virgin

TO THE INPUT DENSITY. Virgin

Virgin

NOTE - FOR THE SAME OPTICAL PATH LENGTHS THROUGH THE LAYER THE Virgin

TRANSMISSION WILL BE EXACTLY THE SAME. HOWEVER, VARYING THE Virgin

DENSITY WILL ALLOW YOU TO MODIFY THE REACTION RATES AT SPECIFIC Virgin

DEPTHS INTO THE LAYER. Virgin

Virgin

COMPUTATION OF INTEGRALS Virgin

---------- Virgin

```
STARTING FROM TOTAL CROSS SECTIONS, REACTION CROSS SECTIONS AND    Virgin
A SOURCE SPECTRUM ALL OF WHICH ARE GIVEN IN TABULAR FORM WITH      Virgin
LINEAR INTERPOLATION BETWEEN TABULATED POINTS ALL REQUIRED         Virgin
INTEGRALS CAN BE DEFINED BY ANALYTICAL EXPRESSIONS INVOLVING       Virgin
NOTHING MORE COMPLICATED THAN EXPONENTIALS. THE INTEGRALS THAT     Virgin
MUST BE EVALUATED ARE OF THE FORM...                               Virgin
                                                                   Virgin
FLUX                                                               Virgin
----                                                               Virgin
(INTEGRAL EK TO EK+1) (S(E)* EXP(-XCT(E)*Z)*DE)                    Virgin
                                                                   Virgin
REACTIONS                                                          Virgin
---------                                                          Virgin
(INTEGRAL EK TO EK+1) (S(E)*XCR(E)*EXP(-XCT(E)*Z)*DE)              Virgin
                                                                   Virgin
WHERE..                                                            Virgin
EK TO EK+1 = LONGEST ENERGY INTERVAL OVER WHICH S(E), XCT(E) AND   Virgin
             XCR(E) ARE ALL LINEARLY INTERPOLABLE.                 Virgin
S(E)       = ENERGY DEPENDENT WEIGHTING SPECTRUM                   Virgin
XCR(E)     = REACTION CROSS SECTION                                Virgin
XCT(E)     = OPTICAL PATH LENGTH (BASED ON TOTAL CROSS SECTION)    Virgin
Z          = MATERIAL THICKNESS                                    Virgin
                                                                   Virgin
S(E), XCR(E) AND XCT(E) ARE ALL ASSUMED TO BE GIVEN IN TABULAR     Virgin
FORM WITH LINEAR INTERPOLATION USED BETWEEN TABULATED POINTS.      Virgin
IN OTHER WORDS BETWEEN TABULATED POINTS EACH OF THESE THREE IS     Virgin
DEFINED BY A FUNCTION OF THE FORM...                               Virgin
                                                                   Virgin
F(E)=((E - EK)*FK+1 + (EK+1 - E)*FK)/(EK+1 - EK)                   Virgin
                                                                   Virgin
EACH OF THESE THREE CAN BE CONVERTED TO NORMAL FORM BY THE         Virgin
CHANGE OF VARIABLES....                                            Virgin
                                                                   Virgin
X=(E - 0.5*(EK+1 + EK))/(EK+1 - EK)                                Virgin
                                                                   Virgin
IN WHICH CASE X WILL VARY FROM -1 (AT EK) TO +1 (AT EK+1) AND      Virgin
EACH FUNCTION REDUCES TO THE NORMAL FORM...                        Virgin
                                                                   Virgin
F(X)=0.5*(FK*(1 - X) + FK+1*(1 + X))                               Virgin
    =0.5*(FK+1 + FK) + 0.5*(FK+1 - FK)*X                           Virgin
                                                                   Virgin
BY DEFINING THE AVERAGE VALUE AND 1/2 THE CHANGE ACROSS THE        Virgin
INTERVAL.                                                          Virgin
                                                                   Virgin
AVF=0.5*(FK+1 + FK)                                                Virgin
DF= 0.5*(FK+1 - FK)                                                Virgin
DE= 0.5*(EK+1 - EK)                                                Virgin
                                                                   Virgin
EACH OF THE THREE FUNCTIONS REDUCES TO THE SIMPLE FORM...          Virgin
                                                                   Virgin
F(X)=AVF+DF*X                                                      Virgin
                                                                   Virgin
AND THE TWO REQUIRED INTEGRALS REDUCE TO...                        Virgin
                                                                   Virgin
FLUX                                                               Virgin
----                                                               Virgin
DE*EXP(-AVXCT*Z) * (INTEGRAL -1 TO +1)                             Virgin
((AVS+DS*X)*EXP(-DXCT*Z*X)*DX)                                     Virgin
                                                                   Virgin
REACTION                                                           Virgin
--------                                                           Virgin
DE*EXP(-AVXCT*Z) * (INTEGRAL -1 TO +1)                             Virgin
((AVS*AVXCR+(AVS*DXCR+AVXCR*DS)*X+DS*DXCR*X*X)*EXP(-DXCT*Z*X)*DX)  Virgin
```

```
                                                                      Virgin
WHERE                                                                 Virgin
                                                                      Virgin
AVXCT   = AVERAGE VALUE OF THE TOTAL CROSS SECTION                    Virgin
AVXCR   = AVERAGE VALUE OF THE REACTION CROSS SECTION                 Virgin
AVS     = AVERAGE VALUE OF THE SOURCE                                 Virgin
DXCT    = 1/2 THE CHANGE IN THE TOTAL CROSS SECTION                   Virgin
DXCR    = 1/2 THE CHANGE IN THE REACTION CROSS SECTION                Virgin
DS      = 1/2 THE CHANGE IN THE SOURCE                                Virgin
DE      = 1/2 THE CHANGE IN THE ENERGY                                Virgin
                                                                      Virgin
NOTE THAT IN THIS FORM THE ENERGY ONLY APPEARS IN FRONT OF THE        Virgin
INTEGRALS AND THE INTEGRALS ARE EXPRESSED ONLY IN TERMS OF THE        Virgin
TABULATED VALUES OF S(E), XCT(E) AND XCR(E). IN PARTICULAR NO         Virgin
DERIVATIVES ARE USED, SO THAT THERE ARE NO NUMERICAL INSTABILITY      Virgin
PROBLEMS IN THE VACINITY OF DISCONTINUITIES IN S(E), XCT(E) OR        Virgin
XCR(E). INDEED, SINCE (EK+1 - EK) APPEARS IN FRONT OF THE INTEGRAL    Virgin
POINTS OF DISCONTINUITY AUTOMATICALLY MAKE ZERO CONTRIBUTION TO       Virgin
THE INTEGRALS.                                                        Virgin
                                                                      Virgin
THE REQUIRED INTEGRALS CAN BE EXPRESSED IN TERMS OF THE THREE         Virgin
INTEGRALS IN NORMAL FORM....                                          Virgin
                                                                      Virgin
F(A,N) = (INTEGRAL -1 TO 1) (X**N*EXP(-A*X)*DX), N=0,1 AND 2.         Virgin
                                                                      Virgin
THESE THREE INTEGRALS CAN BE EVALUATED TO FIND...                     Virgin
                                                                      Virgin
N=0                                                                   Virgin
---                                                                   Virgin
F(A,0) = (EXP(A)-EXP(-A))/A                                           Virgin
                                                                      Virgin
N=1                                                                   Virgin
---                                                                   Virgin
F(A,1) = ((1-A)*EXP(A)-(1+A)*EXP(-A))/(A*A)                           Virgin
                                                                      Virgin
N=2                                                                   Virgin
---                                                                   Virgin
F(A,2) = ((2-2*A+A*A)*EXP(A)-(2+2*A+A*A)*EXP(-A))/(A*A*A)             Virgin
                                                                      Virgin
HOWEVER THESE EXPRESSIONS ARE NUMERICALLY UNSTABLE FOR SMALL          Virgin
VALUES OF A. THEREFORE FOR SMALL A THE EXPONENTIAL IN THE             Virgin
INTEGRALS ARE EXPANDED IN A POWER SERIES...                           Virgin
                                                                      Virgin
EXP(-AX)=1.0-(AX)+(AX)**2/2-(AX)**3/6+(AX)**4/24-.....                Virgin
        =(SUM K=0 TO INFINITY) (-AX)**K/(K FACTORIAL)                 Virgin
                                                                      Virgin
AND THE INTEGRAL REDUCES TO THE FORM....                              Virgin
                                                                      Virgin
(SUM K=0 TO INFINITY) ((-A)**K/(K FACTORIAL)) *                       Virgin
(INTEGRAL -1 TO 1) (X**(N+K))*DX                                      Virgin
                                                                      Virgin
WHICH CAN BE ANALYTICALLY EVAULATED TO FIND....                       Virgin
(K(N) = K FACTORIAL)                                                  Virgin
                                                                      Virgin
N=0                                                                   Virgin
---                                                                   Virgin
F(A,0) = 2*(1+(A**2)/K(3)+(A**4)/K(5)+(A**6)/K(7)+....                Virgin
                                                                      Virgin
N=1                                                                   Virgin
---                                                                   Virgin
F(A,1) = -2*A*(2/K(3)+4*(A**2)/K(5)+6*(A**4)/K(7)+8*(A**6)/K(9)+..    Virgin
                                                                      Virgin
N=2                                                                   Virgin
```

```
---                                                                  Virgin
F(A,2) = 2*(2/K(3)+3*4*(A**2)/K(5)+5*6*(A**4)/K(7)+                  Virgin
         7*8*(A**6)/K(9)+....                                        Virgin
                                                                     Virgin
THESE EXPANSIONS ARE USED WHEN THE ABSOLUTE VALUE OF A IS LESS       Virgin
THAN 0.1. BY TRUNCATING THE ABOVE SERIES BEFORE A**8 THE ERROR       Virgin
RELATIVE TO THE LEADING TERM OF THE SERIES WILL BE 10**(-10),        Virgin
YIELDING 10 DIGIT ACCURACY.                                          Virgin
                                                                     Virgin
AFTER EVALUATING THE ABOVE FUNCTIONS, EITHER DIRECTLY OR BY USING    Virgin
THE EXPANSION THE TWO REQUIRED INTEGRALS CAN BE WRITTEN AS...        Virgin
                                                                     Virgin
FLUX                                                                 Virgin
----                                                                 Virgin
DE*EXP(-AVXCT*Z)*(AVS*F(A,0) + DS*F(A,1))                            Virgin
                                                                     Virgin
REACTIONS                                                            Virgin
---------                                                            Virgin
DE*EXP(-AVXCT*Z)*                                                    Virgin
(AVS*AVXCR*F(A,0) + (AVS*DXCR+AVXCR*DS)*F(A,1) + DS*DXCR*F(A,2))     Virgin
                                                                     Virgin
INPUT FILES                                                          Virgin
-----------                                                          Virgin
FILENAME  UNIT  DESCRIPTION                                          Virgin
--------  ----  -----------                                          Virgin
INPUT       2   INPUT LINES                                          Virgin
ENDFIN     10   EVALUATED DATA IN ENDF/B FORMAT                      Virgin
                                                                     Virgin
OUTPUT FILES                                                         Virgin
------------                                                         Virgin
FILENAME  UNIT  DESCRIPTION                                          Virgin
--------  ----  -----------                                          Virgin
OUTPUT      3   OUTPUT LISTING                                       Virgin
                                                                     Virgin
SCRATCH FILES                                                        Virgin
-------------                                                        Virgin
FILENAME  UNIT  DESCRIPTION                                          Virgin
--------  ----  -----------                                          Virgin
SCR1       12   REACTION, FLUX AND CROSS SECTION RESULTS (BCD)       Virgin
                (SORTED AT END OF RUN AND OUTPUT SEPARATELY)         Virgin
SCR2       13   TALLY GROUP ENERGY BOUNDARIES (BINARY)               Virgin
SCR3       14   SOURCE SPECTRUM (BINARY)                             Virgin
SCR4       15   TOTAL CROSS SECTION (BINARY)                         Virgin
SCR5       16   REACTION CROSS SECTION (BINARY)                      Virgin
                                                                     Virgin
OPTIONAL STANDARD FILE NAMES (SEE SUBROUTINE FILIO1 AND FILEIO2)     Virgin
-------------------------------------------------------------------  Virgin
UNIT  FILE NAME   FORMAT                                             Virgin
----  ----------  ------                                             Virgin
  2   VIRGIN.INP   BCD                                               Virgin
  3   VIRGIN.LST   BCD                                               Virgin
 10   ENDFB.IN     BCD                                               Virgin
11-15 (SCRATCH)   BINARY                                             Virgin
 16   PLOTTAB.CUR PLOTTAB OUTPUT FORMAT DATA                         Virgin
                                                                     Virgin
INPUT LINES                                                          Virgin
-----------                                                          Virgin
ANY NUMBER OF CASES MAY BE RUN ONE AFTER THE OTHER. AFTER THE        Virgin
FIRST CASE HAS BEEN RUN THE FOLLOWING CASES MAY USE THE SAME         Virgin
THICKNESSES, GROUP STRUCTURE AND SPECTRUM AS THE PRECEDING CASE.     Virgin
IN ADDITION THE TRANSMITTED SPECTRUM FROM ONE CASE MAY BE USED       Virgin
AS THE INCIDENT SPECTRUM IN THE NEXT CASE, TO ALLOW MULTIPLE         Virgin
LAYERS OF DIFFERENT MATERIALS.                                       Virgin
```

```
                                                                    Virgin
LINE  COLS.  FORMAT  DESCRIPTION                                   Virgin
----  -----  ------  ----------                                    Virgin
   1   1-60   ENDF/B INPUT DATA FILENAME                          Virgin
                 (STANDARD OPTION = ENDFB.IN)                      Virgin
                                                                   Virgin
LEAVE THE DEFINITION OF THE FILENAMES BLANK - THE PROGRAM WILL     Virgin
THEN USE STANDARD FILENAMES.                                       Virgin
                                                                   Virgin
 2-3   1-72   18A4   TWO LINE TITLE DESCRIBING PROBLEM            Virgin
   4   1- 6    I6    ZA (1000*Z+A) OF TARGET FOR TOTAL            Virgin
       7-11    I5    MT OF TOTAL                                  Virgin
      12-22   E11.4  DENSITY FOR TOTAL                            Virgin
      23-28    I6    ZA (1000*Z+A) OF TARGET FOR REACTION         Virgin
      29-33    I5    MT OF REACTION                               Virgin
                     = 0 - NO REACTION CALCULATION (ONLY FLUX).   Virgin
                     = GREATER THAN 0 - CALCULATE REACTIONS.      Virgin
      34-44   E11.4  DENSITY FOR REACTION                         Virgin
      45-50    I6    NUMBER OF TARGET THICKNESSES                 Virgin
                     = GREATER THAN 0 = READ FROM INPUT           Virgin
                       (1 TO 2000 ALLOWED)                       Virgin
                     =  0 = SAME AS LAST CASE                     Virgin
      51-55    I5    NUMBER OF TALLY GROUPS                       Virgin
                     (REMEMBER NUMBER OF GROUP BOUNDARIES         Virgin
                     IS ONE MORE THAN THE NUMBER OF GROUPS)       Virgin
                     UP TO 2000 GROUPS ARE ALLOWED                Virgin
                     BUILT-IN GROUP STRUCTURES.                   Virgin
                     = GREATER THAN 0 = READ FROM INPUT           Virgin
                     =  0 TART 175 GROUPS                         Virgin
                     = -1 ORNL  50 GROUPS                         Virgin
                     = -2 ORNL 126 GROUPS                         Virgin
                     = -3 ORNL 171 GROUPS                         Virgin
                     = -4 SAND-II 620 GROUPS..1.0D-4 eV TO 18 MEV Virgin
                     = -5 SAND-II 640 GROUPS..1.0D-4 eV TO 20 MEV Virgin
                     = -6 WIMS 69 GROUPS                          Virgin
                     = -7 GAM-I 68 GROUPS                         Virgin
                     = -8 GAM-II 99 GROUPS                        Virgin
                     = -9 MUFT 54 GROUPS                          Virgin
                     =-10 ABBN 28 GROUPS                          Virgin
                     =-11 TART 616 GROUPS TO  20 MeV              Virgin
                     =-12 TART 700 GROUPS TO   1 GeV              Virgin
                     =-13 SAND-II 665 GROUPS..1.0D-5 eV TO 18 MEV Virgin
                     =-14 SAND-II 685 GROUPS..1.0D-5 eV TO 20 MEV Virgin
                     =-15 TART 666 GROUPS TO 200 MeV              Virgin
                     =-16 SAND-II 725 GROUPS..1.0D-5 eV TO  60 MEV Virgin
                     =-17 SAND-II 755 GROUPS..1.0D-5 eV TO 150 MEV Virgin
                     =-18 SAND-II 765 GROUPS..1.0D-5 eV TO 200 MEV Virgin
                     =-19 UKAEA  1102 GROUPS..1.0D-5 eV to   1 GeV Virgin
      56-60    I5    NUMBER OF POINTS IN SOURCE SPECTRUM          Virgin
                     (MUST BE AT LEAST TWO POINTS)                Virgin
                     = GREATER THAN 1 = READ FROM INPUT           Virgin
                     =  0 = SAME AS LAST CASE                     Virgin
                     = -1 = CONSTANT (ENERGY INDEPENDENT)         Virgin
                     = -2 = 1/E                                   Virgin
                     = -3 = BLACKBODY - PHOTON SPECTRUM           Virgin
                     = -4 = BLACKBODY - ENERGY SPECTRUM           Virgin
                     = -5 = TRANSMITTED SPECTRUM FROM LAST CASE   Virgin
                     NOTE, ALL SPECTRA, EXCEPT THE TRANSMITTED    Virgin
                     SPECTRUM FROM THE LAST CASE, WILL BE         Virgin
                     NORMALIZED SUCH THAT ITS INTEGRAL OVER       Virgin
                     ENERGY WILL BE UNITY.                        Virgin
      61-64  1X,3I1  SPATIALLY DEPENDENT OUTOUT                   Virgin
                     = 0 = NO                                     Virgin
```

```
                      = 1 = YES                                          Virgin
                      FOR THE 3 QUANTITIES                               Virgin
                      COLUMN 67 FLUX                                     Virgin
                             68 REACTIONS                                Virgin
                             69 AVERAGE CROSS SECTION                    Virgin
      65-65    I1     ENERGY DEPENDENT OUTOUT                            Virgin
                      = 0 = NONE                                         Virgin
                      = 1 = INCIDENT SPECTRUM                            Virgin
                      = 2 = TRANSMITTED SPECTRUM                         Virgin
                      = 3 = INCIDENT REACTIONS                           Virgin
                      = 4 = TRANSMIITED REACTIONS                        Virgin
                      = 5 = TOTAL CROSS SECTION                          Virgin
                      = 6 = REACTION CROSS SECTION                       Virgin
   5   1-11   E11.4   BLACKBODY TEMPERATURE IN eV                        Virgin
      12-22   E11.4   FLUX NORMALIZATION                                 Virgin
      23-33   E11.4   REACTION NORMALIZATION                             Virgin
                      CALCULATIONS WILL BE BASED ON THE SPECTRUM         Virgin
                      AND CROSS SECTIONS AS READ. AT OUTPUT THE          Virgin
                      RESULTS WILL BE MULTIPLIED BY THESE                Virgin
                      NORMALIZATION FACTORS.                             Virgin
      34-44    I11    DENSITY PROFILE                                    Virgin
                      = 0 - UNIFORM - BASED ON TOTAL DENSITY             Virgin
                      = 1 - UNIFORM - TOTAL + REACTION DENSITY           Virgin
                      = 2 - TOTAL + LINEAR REACTION                      Virgin
                      = 3 - LINEAR (TOTAL + REACTION)                    Virgin
                      = 4 - TOTAL + SQUARE REACTION                      Virgin
                      = 5 - SQUARE (TOTAL + REACTION)                    Virgin
                      = 6 - TOTAL + CUBIC REACTION                       Virgin
                      = 7 - CUBIC (TOTAL + REACTION)                     Virgin
 6-N   1-66  6E11.4   TARGET THICKNESSES IN CM                           Virgin
                      IF SAME AS LAST CASE THIS SECTION IS NOT           Virgin
                      INCLUDED IN THE INPUT.                             Virgin
VARY   1-66  6E11.4   TALLY GROUP ENERGY BOUNDARIES                      Virgin
                      (NUMBER OF BOUNDARIES IS ONE MORE THAN             Virgin
                      THE NUMBER OF TALLY GROUPS)                        Virgin
                      IF THE STANDARD OPTION (-14 TO 0) IS               Virgin
                      SELECTED THIS SECTION IS NOT INCLUDED              Virgin
                      IN THE INPUT                                       Virgin
VARY   1-66  6E11.4   SOURCE SPECTRUM IN ENERGY (eV)-SOURCE PAIRS        Virgin
                      (MUST BE AT LEAST TWO POINTS)                      Virgin
                      IF STANDARD OPTION (-5 TO 0) IS SELECTED THIS      Virgin
                      SECTION IS NOT INCLUDED IN THE INPUT               Virgin
                                                                         Virgin
ANY NUMBER OF CASES MAY BE RUN ONE AFTER ANOTHER.                        Virgin
                                                                         Virgin
EXAMPLE INPUT NO. 1                                                      Virgin
------------------                                                       Virgin
CALCULATE THE UNCOLLIDED FLUX AND CAPTURE (MT=102) THROUGH               Virgin
30 CM OF IRON (DENSITY 7.87 G/CC). TALLY THE RESULTS USING               Virgin
THE TART 175 GROUP STRUCTURE. THE SOURCE WILL BE CONSTANT                Virgin
FROM 1 KEV TO 20 MEV. USE THE STANDARD ENDF/B INPUT DATA                 Virgin
FILENAME.                                                                Virgin
                                                                         Virgin
ENDFB.IN                                                                 Virgin
IRON 0 TO 30 CM THICK.                                                   Virgin
CONSTANT SOURCE FROM 1 KEV TO 20 MEV.                                    Virgin
 26000    1 7.8700D+ 0 26000  102 7.8700D+ 0     2    0    2 1100      Virgin
 0.0000D+ 0 1.0000D+ 0 1.0000D+ 0          0 0.0000D+00                  Virgin
 0.0000D+00 3.0000D+01                                                   Virgin
 1.0000D+03 1.0000D+00 2.0000D+07 1.0000D+00                             Virgin
                                                                         Virgin
EXAMPLE INPUT NO. 2                                                      Virgin
------------------                                                       Virgin
```

```
     CALCULATE THE UNCOLLIDED PHOTON FLUX THROUGH A MIXTURE OF SILICON  Virgin
     AND IRON FOR 100 MEV PHOTONS INCIDENT. THE TRANSMISSION WILL BE    Virgin
     CALCULATED FOR 21 THICKNESSES VARYING BETWEEN 0 AND 1 CM. THERE    Virgin
     WILL BE ONLY 1 TALLY GROUP SPANNING A VERY NARROW ENERGY RANGE     Virgin
     NEAR 100 MEV, AND THE SOURCE SPECTRUM WILL BE CONSTANT OVER THE    Virgin
     SAME ENERGY RANGE. USE THE STANDARD ENDF/B INPUT DATA FILENAME     Virgin
     BY LEAVING THE FIRST INPUT LINE BLANK.                             Virgin
                                                                        Virgin
     (THIS IS A BLANK LINE TO USE THE STANDARD INPUT FILENAME)          Virgin
     100 MEV PHOTONS                                                    Virgin
     SILICON + 5 % IRON                                                 Virgin
      14000  521 2.30000+ 0 26000  521 1.15000- 1    21    1    2 1000  Virgin
      0.00000+ 0 1.00000+ 0 1.00000+ 0          1 0.00000+00            Virgin
      0.00000+00 5.00000-01 1.00000+00 1.50000+00 2.00000+00 2.50000+00 Virgin
      3.00000+00 3.50000+00 4.00000+00 4.50000+00 5.00000+00 5.50000+00 Virgin
      6.00000+00 6.50000+00 7.00000+00 7.50000+00 8.00000+00 8.50000+00 Virgin
      9.00000+00 9.50000+00 1.00000+01                                  Virgin
      9.99000+ 7 1.00100+ 8                                             Virgin
      9.99000+ 7 1.00000+ 4 1.00100+ 8 1.00000+ 4                       Virgin
                                                                        Virgin
=========================================================================== Virgin
```